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(54) Title: DEVICE FOR RELIABLE DETONATION-IMPULSE CLEANING OF THE HEATING SURFACES OF POWER ENGINEERING AND OTHER BOILERS DURING OPERATION

(57) Abstract:

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Device for reliable detonation-impulse cleaning of the heating surfaces of power engineering and other boilers during operation

Area of technology of the invention:

The invention lies in the field of power engineering, especially the field of application of shock waves for periodic cleaning of the heating surfaces of power engineering and other boilers without halting the operation.

According to the International Patent Classification the invention corresponds to symbol F 28 G 13/00.

Technical problem:

The technical problem which is solved by this invention is defined as follows: how to clean the flame-smoke side of heating surfaces without shutting down the boiler. How to design it so that this cleaning is provided by a series of shock waves that will be generated by detonation combustion of suitable reagents in a special device situated outside of the boiler. How, during the time of filling of the device with a mixture of explosive reagents, and without installing closure elements, to prevent the penetration of boiler smoke gases and ash inside the device for detonation-impulse cleaning and at the same time how to ensure that the technical solution to this problem interferes the least with the propagation of the shock waves from the device into the boiler volume. How to ensure that the technical solution of the mentioned problem is sufficient even when the open end of the device for detonation-impulse cleaning is introduced into the zones of the boiler with high temperature and/or temporary excess pressure in the smoke gases. How to enable, by a particular design solution, the undisturbed working or effective reactivation of the device even in the event that its interior nevertheless gets fouled with ash or condensate from the boiler smoke gases and, finally, how to enable the device for impulse-detonation cleaning

to work reliably even under conditions of temporary or lengthy unavailability of the sealing medium.

The defined technical problem is solved by this invention

DEVICE FOR RELIABLE DETONATION-IMPULSE CLEANING OF THE HEATING SURFACES OF POWER ENGINEERING AND OTHER BOILERS DURING OPERATION

Prior art:

In the existing practice, for removal of deposits from the flame-smoke side of boiler heating surfaces, a number of conventional methods are used, with more or less success, such as water or steam blowers, "steel rain", vibrators, and the like. More recently, however, essentially new methods are also being developed for this purpose. One of them is the method of detonation-impulse cleaning, which has been developed since the early seventies in the USSR (Kazan University and "Uralenergochermet") and in Czechoslovakia (VUZES -- Brno). The method is based on removing deposits by shock waves of controlled intensity, which are generated by detonation combustion of suitable reagents introduced into a specially shaped detonation volume, situated outside the boiler. Previously measured and mixed reagents are introduced directly into the detonation volume, which is usually in the form of a pipe with one closed end (the detonation pipe), and they are then burned directly in the detonation volume, usually by an automotive spark plug installed in the wall, near the closed end of the pipe.

The supplying and igniting of the mixture alternate periodically, and the shock waves produced are emitted into the boiler through the second, open end of the detonation pipe, which end does not have any closure elements, and is not outfitted with any other elements to prevent the penetration of smoke gases and ash from the interior of the boiler into the space of the detonation pipe intended for generation of the shock waves.

This device for detonation-impulse cleaning of boiler heating surfaces can work successfully only on certain boilers, and only if connected by its open end to a specially chosen sites of these boilers. Otherwise, because of pulsations during the combustion in the boiler, smoke gases and ash will get from the boiler into the interior of the detonation pipe, which passivates the entire device for detonation-impulse cleaning, renders it very unsafe

in operation, or permanently disables it. The detonation pipes of the device with this design are also subject to physical failure, both on account of the intense heat transfer from the pulsating smoke gases from the boiler to the walls of the open end of the pipe, and on account of the aggressive action of the solution of sulfuric acid formed by condensation of a portion of the smoke gases at its closed end.

Description of the solution of the technical problem:

The invention entitled "Device for reliable detonation-impulse cleaning of the heating surfaces of power engineering and other boilers during operation" is shown on the drawings, namely:

Fig. 1 -- shows the invention in two basic projections: profile and top view.

Fig. 2 -- shows feature "x" in transverse and lengthwise section; detail of the sealing of the open end of the detonation pipe.

Fig. 3 -- shows a view of the invention in section A-A, showing the structural design of the system for suctioning of smoke gases from inside the detonation pipe, as well as for separation of ash from the suctioned smoke gases.

Fig. 4 -- shows section B-B through the system for suctioning of smoke gases from inside the detonation pipe, in which separation of ash from the suctioned smoke gases is provided.

The structural design of this invention eliminates the shortcomings mentioned in the prior art, since the open end of the device for reliable detonation-impulse cleaning of the heating surfaces is realized with a sealing system (items 10-15 and item 29, Fig. 1 and 2), whose nozzles (10) are positioned so as to interfere minimally with the nature of the generated shock waves, while at the same time, by suitably directed jets of an appropriate medium, such as air, sufficiently developed exactly at the open end of the device, they prevent the penetration of boiler smoke gases and ash into the detonation pipe (1), while also affording a cooling of the walls of the detonation pipe at its open end. By this structural design, the electrical ignition source (4) is situated outside of the wall of the detonation pipe and installed in an auxiliary pipe (5), which is connected by a throttle (3) to the main line (2) for filling the detonation pipe with reagents, thereby enabling igniting of the mixture and

undisturbed functioning of the device even in event of a certain amount of ash getting into and remaining in the interior of the detonation pipe.

In the event that, out of necessity, a rather large quantity of ash or condensate builds up inside the detonation pipe, the entire device for detonation-impulse cleaning can easily be reactivated in that the contaminants built up at the closed end of the detonation pipe are removed through a suitable opening (7) with cover (8), and after this the contaminants are removed from the inside of the walls of the detonation pipe by generating several initial shock waves into the atmosphere through a maintenance opening (6) situated in an appropriate place. Of course, in the event that the boiler plant does not have the proper medium available for a short time, or in general, which is needed to supply the nozzles (10) for sealing the open end of the detonation pipe, it is possible to suck out the ash-laden smoke gases by means of the boiler's or a certain other ventilator from the device for detonation-impulse cleaning through several suction pipes (16), manifolds for inertial and gravitational separation of ash (17), and suction pipes (22) with fittings for adjustment of partial vacuum (23) and (24).

The design of the device for reliable detonation-impulse cleaning of the heating surfaces of power engineering and other boilers during operation includes, as one of its main elements, a detonation pipe (1), which is closed at one end, while at its other, open end, serving to emit the shock waves produced into the boiler space, it is realized without closure elements. The detonation pipe at the open end can, if required, branch into two or more outlets, which lead into the interior of the boiler (31) at certain locations. The open end of the detonation pipe (1) freely expands in relation to the structure of the boiler, while the seal of the boiler in relation to the atmosphere is protected at this place by means of packing boxes (9).

Penetration of boiler smoke gases and ash into the inside of the device is prevented by the design of the system for sealing the open end of the detonation pipe by fluid jets. This sealing system also serves to cool the walls in the zone of the open end of the detonation pipe, and it consists of a suitable number of appropriately placed nozzles (10) connected to manifolds (11), whose number corresponds to the number of branches of the open end of the detonation pipe. The manifolds (11) of the sealing system are connected by flanged joints and PARRAP accordion pipes (12) to the fluid distribution pipe (13), in which are installed a regulating (14) and a shutoff (15) valve, after a blower (29). The amount (1) by which the sealing nozzles (10) are situated before the open end of the detonation pipe (1),

as well as the diameter of the outlet cross section of the nozzles (d_0), that is to say the radial angle (φ) and axial angle of their positioning (γ), are such (Fig. 2) that the jets precisely at the open end of the detonation pipe are sufficiently developed (d_k) for a symmetrical arrangement, and with minimal energy dissipation they overlap each other sufficiently, making a curtain having sufficient momentum available to it at the open end of the detonation pipe, which curtain is impermeable to the boiler smoke gases and ash. The sealing system thus installed, in a mechanical sense, does not substantially influence the emission of the shock waves from the device for detonation-impulse cleaning into the boiler. The device is filled with explosive mixture at two levels, located at the closed end, in such a way that previously measured quantities of reagents, after being mixed, are forced into the interior of the detonation pipe (1) across a check valve (25), and then across the main (2) and auxiliary (5) filling pipe. The flow through the auxiliary pipe (5), which serves for the initial ignition of the mixture and in which is placed an ignition source - an electric spark generator (4), is regulated by selection of an appropriate throttle (3). In this way, the ignition source (4) is protected from the passivating action of the ash and condensate from the smoke gases which might nevertheless get into the interior of the device, and the device also functions reliably in such conditions, except for this. Larger quantities of ash and/or condensate that build up inside the device - the detonation pipe (1) in exceptional situations, such as a lengthy standstill, can be removed through the opening (7), on which there is a lid (8) connected by screws. Reactivation of the device in the sense of knocking down the ash from the inner surface of the walls of the detonation pipe will be done in this case by generating several initial shock waves into the atmosphere through the maintenance opening, whose cover (6) is reinforced by a beam (26), which is tightened by screws (27). The maintenance opening with cover (6) is placed behind a turbulizer (28), and in relation to the closed end of the detonation pipe it is placed at a distance equal to at least fifteen times the cross sectional diameter of the detonation pipe. In situations where, out of necessity, there is a temporary interruption or the boiler plant cannot generally obtain any suitable medium for the sealing (which can be, for example, heated or cooled air, compressed to 2-4 kPa), the smoke gases of moderate temperature can be sucked out from the device by means of the boiler's or some other fan (30), through several pipes (16), arranged symmetrically about the periphery of the detonation pipe and making an acute angle (δ) in relation to the possible flow of smoke gases, said pipes being connected to a manifold in the form of a torus (17). At the bottom end, the manifold (17) terminates in a hopper (18), which serves to keep the ash separated from the smoke gases during the flow through the manifold, and is emptied periodically from the hopper by opening a threaded cover (19). The smoke gases, partially freed of ash, are taken away from the top part of the

manifold by an axial compensator with flanges (21) and a suction pipe (22). Shutoff and regulating fittings (23) and (24) serve to regulate the partial vacuum in the manifold (17).

Patent claims:

1. Device for reliable detonation-impulse cleaning of the heating surfaces of power engineering and other boilers during operation, characterized in that the ignition source (4) is placed outside of the detonation pipe (1) and situated in an auxiliary filling pipe (5), in that the auxiliary filling pipe (5) is connected, via a throttle (3), to the main filling pipe (2), upstream from which is placed a return valve (25), in that at the closed end of the detonation pipe (1) there is made a cleaning opening (7) with flanged cover (8), and in that on the detonation pipe (1), behind a turbulizer (28), there is made a maintenance opening, which also serves to reactivate the chamber by occasional generation of shock waves into the atmosphere, with a cover (6) that is reinforced by a beam (26) secured by screws (27).

2. Device for reliable detonation-impulse cleaning of the heating surfaces of power engineering and other boilers during operation as claimed in claim 1, characterized in that, upstream from the open end of the detonation pipe (1), there is placed a sealing system, which consists of an appropriate number of suitably positioned nozzles (10), connected to manifolds (11), which are joined by means of PARRAP accordion pipes with flanges (12) to a distribution pipe for supplying an appropriate sealing fluid (13), which is pressurized by a fan (29), and in that a regulating (14) and a shutoff (15) valve are placed on the pipe for supply of sealing fluid (13) behind the fan (29).

3. Device for reliable detonation-impulse cleaning of the heating surfaces of power engineering and other boilers during operation as claimed in claim 1, characterized in that, at an appropriate place on the detonation pipe (1), at an acute angle with respect to the possible flow of boiler smoke gases, there is placed a sufficient number of pipes for suctioning of smoke gases and ash (16), arranged uniformly about the periphery of the detonation pipe, being connected to a manifold in the form of a torus (17), whose bottom part terminates in a hopper (18) with a threaded cover (19), which is used for occasional emptying of the ash separated from the smoke gases, in that the upper part of the manifold (17) is designed with a cover for cleaning (20), while it is connected via an axial compensator with flanges (21) to a suction pipe (22), having a built-in stop valve (23) and regulating valve (24) for adjusting the partial vacuum in the manifold (17), and in that the suction pipe (22) is connected to the intake side of the fan (30).

4. Device for reliable detonation-impulse cleaning of the heating surfaces of power engineering and other boilers during operation as claimed in claim 2, characterized in that, in the system for sealing the open end of the detonation pipe (1), in place of the blower (29), one may alternatively use heated or cooled air from the boiler's heating system, such that the distribution pipe for supplying sealing fluid (13) with a regulating (14) and a shutoff (15) valve is connected to the appropriate place of the fresh air channel, which is joined to the pressure side of the boiler pressure fans.

5. Device for reliable detonation-impulse cleaning of the heating surfaces of power engineering and other boilers during operation as claimed in claim 3, characterized in that, as an alternative, one can omit the intake fan (13) from the system for suctioning of smoke gases and ash from the interior of the detonation pipe (1), such that the suction pipe (22) with shutoff (23) and regulating (24) valve is connected to the intake side of the fan for suctioning of smoke gases from the boiler.

Summary of the essence of the invention:

The invention refers to a device for reliable detonation-impulse cleaning of the heating surfaces of power engineering and other boilers during operation, by means of which shock waves of controlled intensity are generated by detonation combustion of suitable reagents and emitted into the gas space of a boiler. The device differs in design from the known solutions in that the electric ignition source is placed outside of the detonation pipe and installed in a special pipe for auxiliary filling, in which pipe the flow of reagents is adjusted by selection of an appropriate throttle, and in that together with appropriately positioned openings for cleaning of the detonation pipe and initial generating of shock waves into the atmosphere the device is rendered reliable in operation and suitable for reactivation after lengthy standstills. Furthermore, in order to prevent penetration of boiler smoke gases and ash into the interior of the device, at the open end of the detonation pipe there is placed a system for sealing by jets of appropriate fluid, e.g. compressed air, and in event of unavailability of fluid for sealing, the smoke gases can be sucked out from the device by a special system which, after separation of the ash, is connected to the intake of the boiler smoke gas fans.

Proposal for best method of economical use of the invention

The device for reliable detonation-impulse cleaning of loose deposits which are usually deposited in the convective portion of a boiler can also be used successfully for removal of harder deposits laid down in the furnace. It is easiest to generate the shock waves by burning a suitable, previously prepared mixture of TNG and air. The length of the detonation pipe must be such as to enable full development of the wave before it reaches the open end, and the acoustic power of the device, which is a function of the volume of the detonation pipe, is chosen in accordance with the thermal power of the boiler for which the device is intended. However, it can be recommended that the shock waves be generated by burning 0.5-1.2 Nm^3 of a suitable mixture of TNG and air under atmospheric conditions in a device whose detonation pipe is 15-25 m long, and whose diameter is 0.2-0.35 m; the speed of the mixture through the auxiliary filling pipe in which the ignition source is placed should not exceed 1.5 m/s, or be less than 0.5 m/s, the turbulizer should be placed 1.2-1.6 m away from the closed end of the detonation pipe, air from the heating system of the boiler should be used for sealing the open end of the device, while 3-5 nozzles with diameter of 20-40 mm should be placed 0.6-1.0 m before the open end of the detonation pipe at an axial angle of 5-10 degrees, and they should be radially turned at an angle of 25-35 degrees. The systems for suctioning of smoke gases should not be placed too close to the open end of the device, while 4 to 6 pipes for suctioning gases and ash from the device of diameter 40-70 mm should be uniformly distributed about the periphery of the detonation pipe, at an angle of 30 degrees in relation to the possible flow of smoke gases through the detonation pipe. The partial vacuum in the suction manifold should not be more than 100-150 Pa. The cleaning of the boiler should be organized so as to generate sufficiently frequently (1 to 6 times in 24 hours) series of 10 to 20 shock waves, and so that the last waves in the series will be the strongest.

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Device for r liabl detonation-impuls cleaning of th h ating surfaces of power engineering and other boilers during opreration

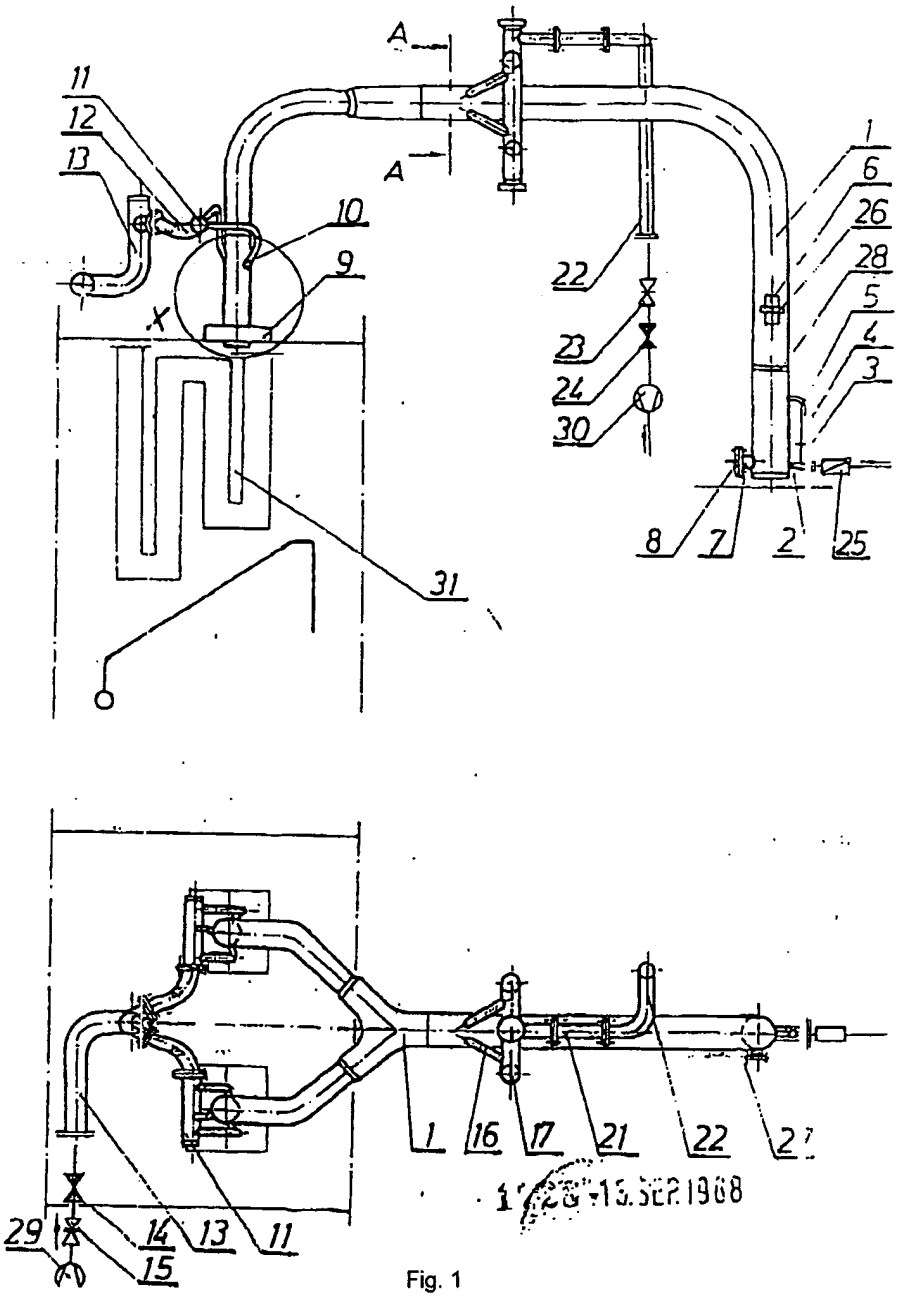

Fig. 1

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Device for reliable detonation-impulse cleaning of th h ating surfac s of power engineering and other boilers during opr ration

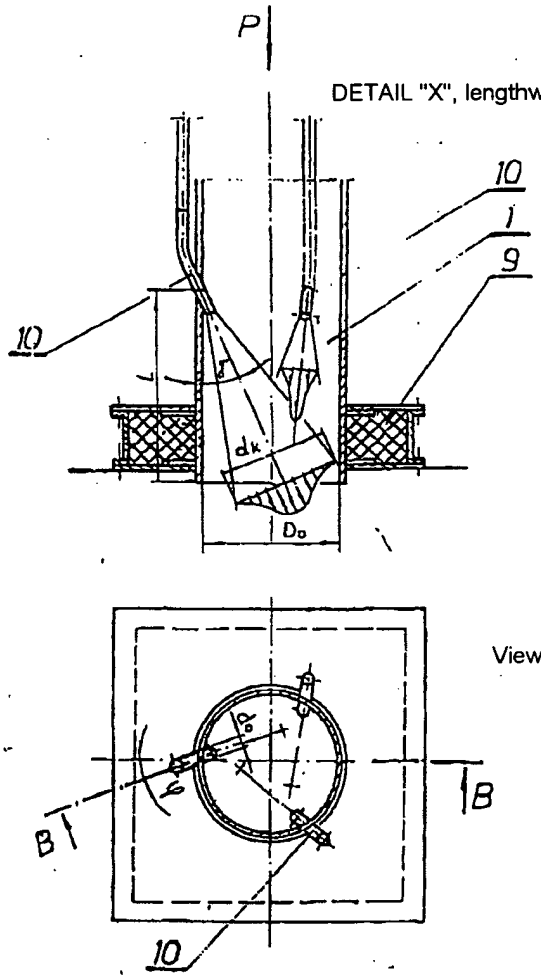

Fig. 2

Smajevic, Izet; dipl. ing.
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Device for reliable detonation-impulse cleaning of the heating surfaces of power engineering and other boilers during opreration